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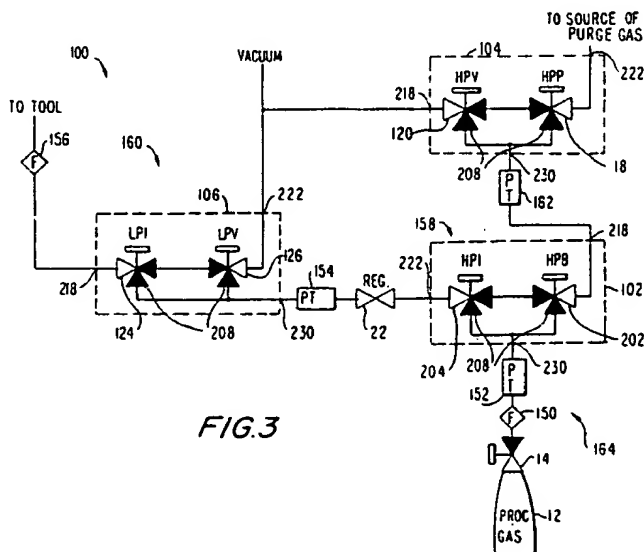
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(54) **Zero Dead-Leg Gas Cabinet.**

(57) A valve assembly for use in a gas cabinet manifold and comprising two valves for selectively controlling flow of a fluid, each of said valves including:  
a valve chamber in which are formed first and second inlet ports and an outlet port; and  
closing mechanism disposed within said valve chamber for selectively closing said outlet port;

the valve assembly further comprising a first conduit connecting the respective first inlet ports of said two valves, a second conduit connecting the respective second inlet ports of said two valves, and means for introducing said fluid into said first conduit.

**FIG.3****EP 0 619 450 A1**

This invention relates to gas distribution equipment and methods, and particularly to an apparatus and method for supplying process gas used in semiconductor manufacturing.

In the semiconductor manufacturing industry, gas cabinets are used to supply high purity process gases used in production. An example of such a process gas is silane, which is used at the processing location, also known as the tool location, in processes such as sputtering and sputter etching.

US Patent Specifications No. 4,989,160, and No. 5,220,517 (whose disclosures are incorporated herein by reference) disclose automated gas cabinets used for supplying process gas in semiconductor manufacturing operations. As noted therein, many process gases used in semiconductor manufacturing are highly toxic, so that safe control of the gases is imperative. At the same time, the delicate nature of semiconductor manufacturing requires that the process gases be delivered to the tool location with an absolute minimum of contaminants.

In order to permit process gas cylinder changes or other manual activities required in operation of a gas cabinet, purge operations like those disclosed in the above referenced patent are carried out in order to prevent exposure of the operator to the toxic process gas. Purge operations are also intended to flush contaminants out of the system of gas carrying conduits, known as a manifold, which is associated with the gas cabinet. As the field of semiconductor manufacture has advanced, the desired density of components in the resulting product has increased and the tolerance for contaminants has decreased. This has led designers of gas cabinet and their associated manifolds to seek to eliminate "dead-legs" in the manifolds, since dead-legs are considered to be sources of contaminants. As is known to those skilled in the art, a "dead-leg" is a section of conduit through which gas does not flow, ie, the equivalent of a cul-de-sac or dead end road.

Attempts have been made in the past to provide a gas cabinet manifold that is free of dead-legs, but those attempts have not been entirely successful. To illustrate this point, reference will be made to Figures 1 and 2, which show prior art arrangements of gas cabinet manifolds.

In Figure 1, reference numeral 10 generally indicates a gas cabinet manifold in accordance with the prior art. The manifold 10 includes a process gas cylinder 12 with an associated cylinder valve 14, a high pressure isolation (HPI) valve 16, a high pressure purge (HPP) valve 18 and a high pressure vent (HPV) valve 20. Manifold 10 also includes a pressure regulator 22, a low pressure isolation (LPI) valve 24 and a low pressure vent (LPV) valve 26.

The manifold 10 further includes a junction point 28 which is connected to the cylinder valve 14 by a conduit section 30. Conduit sections 32, 34 and 36 respectively connect the junction point 28 with HPI valve 16, HPP valve 18, and HPV valve 20. When manifold 10 is being operated to supply process gas to a tool location, the process gas flows from cylinder 12 through valve 14, conduit section 30, junction point 28, conduit section 32, HPI valve 16, pressure regulator 22 and LPI valve 24 on its way to the tool location (not shown). It will be noted that during such an operation, process gas does not flow through conduit sections 34 and 36, so that those sections constitute dead-legs during process gas supply operations. Moreover, during a purge-to-change-process-gas-cylinder operation, HPI valve 16 is closed and HPV valve 20 and HPP valve 18 are alternately opened and closed to place conduit sections 30 alternately in communication with a vacuum venturi and with a source of purge gas. However, during such purge operations conduit section 32 does not have gas flowing there-through, and so constitutes a dead-leg during purge operations.

Referring now to Figure 2, reference numeral 10' indicates another prior art manifold provided in an attempt to eliminate dead-legs during delivery of process gas. Elements of manifold 10' which correspond to elements of Figure 1 have been given the same reference numerals. In the manifold 10' shown in Figure 2, it will be noted that HPP valve 18', HPV valve 20' and LPV valve 26' are all shown as "3-port" valves which have a selectively closable port and two other ports which are always in fluid communication with each other, regardless of whether the closable port is open or closed. Accordingly, during delivery of process gas, the gas flows from cylinder 12 via cylinder valve 14, HPP valve 18', HPV valve 20', HPI valve 16, pressure regulator 22, LPV valve 26' and LPI valve 24 on its way to the tool location. This flow path has no dead-leg associated with it, so that during process gas delivery operations, manifold 10' is dead-leg free. However, during purge operations, in which HPI valve 16 is closed and HPP valve 18' and HPV valve 20' are alternately opened and closed, a conduit section 38 between HPI valve 16 and HPV valve 20' experiences no flow of gas therethrough, and so constitutes a dead-leg during purge operations. As a result, contaminants may remain in conduit section 38 on the completion of a purge operation, leading to the possibility of contamination of the semiconductors subsequently manufactured at the tool location. Therefore, the dead legs also have not been eliminated from the Figure 2 system.

Accordingly, the invention is concerned with the provision of a process gas distribution system

and method in which the level of contaminants in the gas is minimized. To this end, it is an object to provide a gas distribution manifold that is substantially free of dead-legs during both purge and process gas delivery operations.

The invention is also concerned with the provision of a valve assembly for use in a process gas distribution manifold in which dead-legs are to be substantially eliminated.

The invention generally is able to provide the foregoing at a reasonable cost and to provide a method for venting high pressure process gas from a gas cabinet manifold with a high degree of safety for operating personnel.

In accordance with the present invention, the foregoing objects are met by the provision of a valve assembly in accordance with Claim 1, in particular one which includes two valves for selectively controlling flow of fluid, with each of the valves including a valve chamber in which are formed first and second inlet ports and an outlet port and a closing mechanism disposed within the valve chamber for selectively closing the outlet port, with the valve assembly also including a first conduit connecting the respective first inlet ports of the two valves, a second conduit connecting the respective second inlet ports of the two valves, and structure for introducing the fluid into the first conduit. Such a valve assembly facilitates construction of a gas cabinet manifold without dead-legs.

In accordance with another feature of the invention, a pair of valves is provided in a manifold for supplying process gas to a tool location, with the manifold including a pressure regulator connected between a high pressure area and a regulated pressure area, and each of the valves including first and second inlet ports and a selectively closable outlet port, the outlet port of one of the valves being connected for fluid communication with a high pressure side of the pressure regulator, the outlet port of the other of the valves being selectively connectable for fluid communication with at least one of a source of purge gas and a source of vacuum, the first inlet ports of the valves being connected in common for fluid communication with a source of process gas, and the second inlet ports of the valves being interconnected for fluid communication therebetween. With this arrangement of valves within a manifold, gases are free to flow through the valve chambers of each of the valves even when the valves are closed, so that neither valve becomes a dead end which forms a dead-let in the manifold.

According to a further feature of the invention, the manifold also includes a second and a third pair of valves with each of the valves of the second and third pairs including first and second inlet ports and a selectively closable outlet port; the outlet

port of one of the second pair of valves being connected for fluid communication with the source of vacuum, the outlet port of the other of the second pair of valves being connected to a source of purge gas, the first inlet ports of the second pair of valves being connected in common for fluid communication with the outlet port of the other of the first pair of valves, the second inlet ports of the second pair of valves being interconnected for fluid communication therebetween, the outlet port of one of the third pair of valves being connected for fluid communication with the tool location, the outlet port of the other of the third pair of valves being connected for fluid communication with the source of vacuum, the first inlet ports of the third pair of valves being connected in common for fluid communication with the pressure regulator, and the second inlet ports of the third pair of valves being interconnected for fluid communication therebetween. In this way, all of the valves required for a dead-leg-free gas cabinet manifold are provided in the form of three valve assemblies, with all of the valves permitting flow-through of gas so that dead-legs are avoided.

According to yet another feature of the invention, a pair of valves is provided in a manifold for supplying process gas to a tool location, with the manifold including a regulated pressure area and the valves each including first and second inlet ports and a selectively closable outlet port, the outlet port of one of the valves being connected for fluid communication with the tool location, the outlet port of the other of the valves being connected for fluid communication with a source of vacuum, the first inlet ports of the valves being connected in common for fluid communication with the regulated pressure area, and the second inlet ports of the valves being interconnected for fluid communication therebetween. As before, each of the valves permits flow-through of gases even when the valves are closed, so that dead-legs are avoided.

According to still another feature of the invention, a pair of valves is provided in a manifold for supplying process gas to a tool location, with the manifold including a high pressure area and the valves each including first and second inlet ports and a selectively closable outlet port, the outlet ports of one of the valves being connected for fluid communication with a source of vacuum, the outlet port of the other of the valves being connected for fluid communication with a source of purge gas, the first inlet ports of the valves being connected in common and being selectively connectable for fluid communication with the high pressure area, and the second inlet ports of the valves being interconnected for fluid communication therebetween. Again, the valves permit flow-through of gas even when closed, so that dead-legs are avoided.

According to another feature of the invention, in a gas cabinet manifold which includes a pressure regulator connected between a high pressure area and a regulated pressure area, a process gas supply line connected to the high pressure area and a valve located in the high pressure area for selectively isolating the pressure regulator from the process gas conduit, a method of purging the process gas supply line includes the steps of closing the valve and flowing a purge gas through a valve chamber of the closed valve to the process gas conduit. In this way, a process gas supply line purge operation is performed without dead-legs in the gas cabinet manifold.

According to another feature of the invention, in a gas cabinet manifold which includes a high pressure area, a regulated pressure area and a pressure regulator connected between the high pressure area and the regulated pressure area, a method of purging the manifold includes the step of venting process gas from the high pressure area by way of the pressure regulator and the regulated pressure area. As a result, purging of process gas from the high pressure area is made safer since high pressure process gas is not directly vented into the atmosphere.

According to another aspect of this method, the gas cabinet manifold has a vent valve for selectively connecting the regulated pressure area to a source of vacuum and an isolation valve for selectively connecting the regulated area to a tool location and the method includes the additional steps of closing the isolation valve and opening the vent valve, with the step of venting process gas including flowing the process gas through a valve chamber of the closed isolation valve to the source of vacuum. In this way, a dead-leg terminating at the low pressure isolation valve is eliminated.

According to another feature of the invention, in a gas cabinet manifold which includes a conduit for providing process gas to a tool location, an isolation valve for selectively connecting the conduit to the tool location and a vent valve for selectively connecting the conduit to a source of vacuum, a method of purging the conduit includes the steps of closing the isolation valve, opening the vent valve, and flowing gas from the conduit to the source of vacuum via a valve chamber of the closed isolation valve. As before, such a method eliminates a dead-leg terminating at the isolation valve.

In accordance with yet another aspect of the invention, a pair of valves is provided in a purge gas manifold for use in association with a gas cabinet manifold, and each of the valves includes first and second inlet ports and a selectively closable outlet port, the outlet port of one of the valves being connected for fluid communication with the

gas cabinet manifold, the outlet port of the other valve being connected for fluid communication with an exhaust vent, the first inlet ports of the valves being connected in common for fluid communication with a source of purge gas, and the second inlet ports being interconnected for fluid communication therebetween. This arrangement eliminates dead-legs in the purge gas manifold.

Reference will now be made, by way of exemplification only, to the accompanying drawings in which:

Figures 1 and 2 are schematic illustrations of gas cabinet manifolds in accordance with the prior art;

Figure 3 is a schematic illustration of a gas cabinet manifold according to the present invention;

Figures 4A-4C are partially schematic cross-sectional views of a dual valve assembly used in the manifold of Figure 3;

Figure 5 is a view looking into the valve chamber of a valve included in the valve assembly of Figures 4A-4C;

Figure 6 is a schematic illustration of a purge gas manifold used in association with the gas cabinet manifold of Figure 3;

Figure 7 is a front elevation view of a manually actuated dual valve assembly used in the purge gas manifold of Figure 6; and

Figures 8A-8D are additional views of the valve assembly of Figure 7.

With reference to the drawings, Figure 3 schematically illustrates a gas cabinet manifold 100 according to the present invention. Elements of manifold 100 that correspond to elements of prior art manifold 10 have been given the same reference numerals.

Manifold 100 includes three dual valve assembly blocks 102, 104 and 106. Although the overall arrangement of manifold 100 differs from the arrangements of prior art manifolds, except for the valve assembly blocks 102, 104 and 106, all of the components of manifold 100 are preferably of conventional types and so will not be described in detail.

Except for a cylinder valve 14, all of the valves required for manifold 100 and included in the valve blocks 102, 104 and 106. Valve blocks 102, 104 and 106 are preferably identical, so that the following description of valve block 102 should be understood to apply also to valve blocks 104 and 106.

Referring now to Figure 4A, valve block 102 includes a substantial valve block body 200 in which valves 202 and 204 are formed. Each of the valves 202 and 204 has a valve chamber 206. Each of the valve chambers 206 has a first inlet port 208 and a second inlet port 210. The valve chamber 206 of valve 204 has an outlet port 214. A conduit

216 connects outlet port 212 of valve 202 to a first port 218 of valve block 102. A conduit 220 connects outlet 214 to a second port 222 of valve block 102. A conduit 224 interconnects the respective first inlet ports 208 of valves 202 and 204, and a conduit 226 interconnects the respective second inlet ports 210 of the valves 202 and 204. In addition, conduit 224 is connected via a conduit 228 to a third port 230 of valve block 102. Each of the conduits 216, 220, 224, 226 and 228, like valve chambers 206 and inlet ports 208, 210 and outlet ports 212 and 214, is formed in valve block body 200, by machining, for example.

Disposed within each of the valve chambers 206 is a diaphragm 232 which is provided for selectively opening or closing outlet port 212 or 214, as the case may be. In Figure 4A each of the diaphragms 232 is shown in its closed position with its open position being represented by a dashed curve 232'. The two-headed arrows 234 represent conventional mechanisms, preferably pneumatic, for controlling the position of diaphragms 232. The mechanisms 234 are used for moving the diaphragm 232 between their open and closed positions.

As best seen in Figure 5, the outlet 212 of valve 202, like the outlet 214 of valve 204, is located within a valve seat 236. Diaphragm 232 and valve seat 236 are fitted and dimensioned so that a seal is formed therebetween when diaphragm 232 is in its closed position. Diaphragms 232 are made of conventional material such as nickel alloy known as "Elgiloy" (produced by Elgiloy Corp.), while the seat 236 is also formed of a conventional material such as the elastomers known as "KEL-F-81" (from 3M) or "Vespel" (from DuPont). It should be understood that the valve block body 200 is also of a conventional material such as 316L VAR or 316L VIM VAR stainless steel, or nickel, or an alloy known as "Hastalloy C22" (from Haynes Corp.).

Alternatively valve seat 236, instead of being formed of elastomer, may be integrally formed in valve block body 200. Also, the diaphragms 232 may be of one of the materials from which block body 200 may be formed.

Valve chamber 206 is formed such that even when a diaphragm 232 is in its closed position so that the corresponding outlet port 212 or 214 is closed, nevertheless the corresponding inlet ports 208 and 210 are still in fluid communication with each other through valve chamber 206 around the base of valve seat 236. Accordingly, regardless of the open or closed state of valves 202 or 204, valve block 102 has a constantly open loop of flow path formed by the conduits 226 and 224, which are connected through the valve chambers 206 and the inlet ports 208 and 210.

It should also be noted that the valves 202 and 204 are arranged in valve block 102 in a mutually opposed orientation. This arrangement allows valve block 102 to be relatively small in size and permits an overall space efficient design for gas cabinet manifold 100. Provision of two valves in a single assembly also minimizes the cost of installing valves in the manifold 100.

Gas cabinet manifold 100 will now be described in more detail. Referring again to Figure 3, it will be seen that process gas cylinder 12 is connected to the port 230 of valve block 102 by way of cylinder valve 14, a filter 150, and a pressure transducer 152. The two valves 202 and 204 of valve block 102 function respectively as a high pressure block (HPB) valve and a high pressure isolation (HPI) valve.

The port 222 of valve block 102 is connected to pressure regulator 22. As is well known to those skilled in the art, pressure regulator 22 serves to reduce the pressure of gas flowing from the process gas cylinder 12 toward the tool location. Pressure regulator 22 is connected by way of a pressure transducer 154 to a port 230 of valve block 106. The two valves of valve block 106 respectively function as a low pressure isolation (LPI) valve and a low pressure vent (LPV) valve and are given the respective reference numerals 124 and 126. The selectively closable outlet port (corresponding to outlet port 212, Figure 4A) of LPI valve 124 is connected to a tool location (not shown) via a port 218 of valve block 106 and a filter 156. The selectively closable outlet port of LPV valve 126 (corresponding to outlet port 214, Figure 4A) is connected via a port 222 of valve block 106 to a conventional source of vacuum such as a venturi (not shown), which, as is well known to those skilled in the art, is provided for applying a vacuum to selected portions of manifold 100 during purge operations. Because of the reduction in pressure provided by pressure regulator 22, the portion of manifold 100 shown to the right of pressure regulator 22 in Figure 3 and between HPB valve 202 and process gas cylinder 12 can be considered a high pressure area 158 of manifold 100. It can also be said that the outlet port 212 of HPI valve 204 is connected to the high pressure side of regulator 22. Moreover, the area shown to the left of regulator 22 in Figure 3 and between LPI valve 124 and LPV valve 126 can be considered a regulated pressure area 160 of manifold 100 and the first inlet ports 208 of LPI valve 124 and LPV valve 126 can be said to be connected (via port 230 of valve block 106) to the regulated pressure side of regulator 22.

The port 218 of valve block 102 is connected by way of a pressure transducer 162 to a port 230 of valve block 104. The two valves of valve block

104 respectively perform the functions of a high pressure vent (HPV) valve and a high pressure purge (HPP) valve and are given the respective reference numerals 120 and 118. The outlet port of HPP valve 118 is connected via port 222 of valve block 104 to a source of purge gas (not shown in Figure 3), and the outlet port of HPV valve 120 is connected to the venturi via port 218 of valve block 104.

From the foregoing it will be understood that the function of HPV valve 120 is to selectively apply vacuum to the high pressure area 158, the function of HPP valve 118 is to selectively apply purge gas to high pressure area 158, the function of HPB valve 202 is to selectively isolate the high pressure area 158 from valve block 104, the function of HPI valve 204 is to selectively isolate the process gas supply, including process gas cylinder 12, from pressure regulator 22 (and hence also from regulated pressure area 160 and from the tool location), the function of LPV valve 126 is to selectively apply vacuum to the regulated pressure area 160, and the function of LPI valve 124 is to selectively isolate regulated pressure area 160 (and hence substantially all of manifold 160) from the tool location.

Pressure transducers 152, 154 and 162 and filters 150 and 156 are all preferably conventional components for a gas cabinet manifold. The pressure transducers are preferably of the type formed of strain gauges attached to the outside of conduits so that no dead-legs or other sources of contamination or restrictions to gas flow are present. Preferably filter 150 is a gasket type for coarse filtration and filter 156 is for fine filtration.

Operation of gas cabinet manifold 100 for delivery of process gas to the tool location will be described with reference to Figures 3 and B. When process gas is being delivered to the tool location, valves 202 (HPB), 120 (HPV), 118 (HPP) and 126 (LPV) are all closed, while the cylinder valve 14 and valves 204 (HPI) and 124 (LPI) are open. Accordingly, process gas flows from process gas cylinder 12 through cylinder valve 14, filter 150, pressure transducer 152, valve chambers 206 of HPB valve 202 and HPI valve 204, outlet port 214 of HPI valve 204 port 222 of valve block 102, pressure regulator 22, pressure transducer 154, port 230 of valve block 106, valve chambers 206 of LPV valve 126 and LPI valve 124, the outlet port of LPI valve 124, port 218 of valve block 106, and filter 156 on its way to the tool location. It will be observed that there are no dead-legs in or along the flow path of the process gas.

Flow of process gas through valve block 102 will now be described in more detail with reference to Figure B.

It will be noted that during process gas delivery operations, the diaphragm 232 of valve 204 is in its open position and the diaphragm 232 of valve 202 is in its closed position. The process gas flow is represented by the arrows A in Figure B, which show the process gas entering conduit 228 through port 230 and then travelling by two paths on its way to outlet port 214 of valve 204. In particular, the first and more direct path is from conduit 228 downward (as shown in Figure B) through conduit 224, entering valve chamber 206 of valve 204 through the inlet port 208 of valve 204 and then exiting through outlet port 214 of valve 204. The second and less direct path is shown as proceeding from conduit 228 in an upward direction (as shown in Figure B) through conduit 224 so that the process gas enters the lower portion of valve chamber 206 of valve 202 (i.e. the portion below diaphragm 232 of valve 202) via inlet port 208 of valve 202. The second flow path continues through valve chamber 206 of valve 202 from its inlet port 208 to its inlet port 210 and then downwardly as shown in Figure B through conduit 226 so that the second flow path enters the valve chamber 206 of valve 204 through the inlet port 210 of valve 204. The two flow paths join together in existing valve 204 via its outlet port 214 and continue on through conduit 220 to port 222. Due to the loop formed by valve chambers 206, inlet ports 208 and 210, and conduits 226 and 224, there are no dead-legs within valve block 102.

The flow of process gas through valve block 106 is essentially the same as in valve block 102, with LPI valve 124 being open and corresponding to HPI valve 204, and LPV valve 126 being closed and corresponding to HPB valve 202. Accordingly, valve block 106 is also free of dead-legs during process gas delivery.

There will next be described operation of the gas cabinet manifold 100 for the purpose of changing the process gas cylinder 12, as is required, for example, when the process gas stored in cylinder 12 has been exhausted. The procedure for changing cylinder 12 can be divided into four stages: (1) pre-purge, during which the toxic process gas is removed from high pressure area 158 to ensure that the operator is not exposed to process gas; (2) cylinder change; (3) post-purge, for removing from manifold 100 contaminants that may have been introduced during the cylinder change; and (4) refill, for refilling the manifold 100 with pure process gas.

#### 1. Pre-Purge

The pre-purge stage is divided into two portions: a valve test and the purging itself.

The first steps of the valve test include closing cylinder valve 14 and LPI valve 124. The venturi is then activated so that a vacuum will be applied to any points of the manifold 100 which are placed in fluid communication with the venturi. Next, HPV valve 120 is opened and pressure transducer 162 is monitored to confirm that a sufficiently low vacuum is present at pressure transducer 162. The next step consists of closing HPV valve 120 and opening LPV valve 126 so that the so that the vacuum is applied to high pressure area 158 through pressure regulator 22. This ensures that high pressure process gas is not released directly into the atmosphere. Instead, the process gas is vented from the high pressure area 158 through pressure regulator 22 and regulated pressure area 160. It will be understood that the process gas flows through the valve chambers of both closed LPI valve 124 and open LPV valve 126 before exiting from valve block 106 through its port 222.

The following step is closed LPV valve 126 and HPI valve 204 and then opening HPV valve 120 and HPB valve 202. This causes vacuum to be applied through HPV valve 120 and HPB valve 202 to the conduit 164 which connects process gas cylinder 12 to manifold 100 (this conduit 164 will sometimes be referred to as the "pigtail"). After evacuation of the pigtail 164, the HPV valve 120 and HPB valve 202 are closed and pressure transducer 152 is monitored for a predetermined period of time to ensure that cylinder valve 14, believed to be closed, is not leaking. If no leak is found, then the valve test portion of the pre-change purge operation is complete and the pre-purging itself begins.

The pre-purging commences with the opening of HPB valve 202. This valve is left open throughout the pre-purging cycles. Next, the HPP valve 118 is opened to admit purge gas at approximately 100 psi into the high pressure area 158 and pigtail 164. More specifically, the purge gas enters valve block 104 through its port 222 and flows through the valve chambers 206 of both valves 120 (HPV) and 118 (HPP) and flows out of valve block 104 through its port 230. The purge gas continues through pressure transducer 162 and enters valve block 102 through its port 218. The gas flows through the valve chambers 206 of both of valves 202 (HPB) and 204 (HPI), and enters pigtail 164 through port 230 of valve block 102.

The flow of purge gas through valve block 102 will be described in more detail with reference to Figure 4C. During the purging, valve 202 is open (i.e. its diaphragm 232 is in the open position) and valve 204 is closed. As before, the flow path is represented by arrows A. As noted above, the purge gas enters valve block 102 through port 218. The purge gas then proceeds via conduit 216 to

valve chamber 206 of valve 202. The gas flow then divides among two paths. One path proceeds from the valve chamber 206 of valve 202 via inlet port 210 and conduit 226 to valve chamber 206 of valve 204. The purge gas flows around the closed diaphragm 232 of valve 204 on its way to inlet port 208 of valve 204, from where the gas flows (upwardly as shown in Figure 4C) in conduit 224 to conduit 228 and out through port 230. Another and more direct gas flow path proceeds from valve chamber 206 of valve 202 downwardly (as shown in Figure 4C) in conduit 224 and then to conduit 228 and out of port 230.

After the purge gas has been applied for a predetermined period of time, HPP valve 118 is closed, and HPV valve 120 is opened to apply vacuum to high pressure area 158 and pigtail 164. The flow paths of gas through valve block 102 during evacuation of high pressure area 158 and pigtail 164 are in reverse directions to the flow paths shown in Figure 4C. At the end of a predetermined period of time, HPV valve 120 is closed and HPP valve 118 is opened again for reapplication of purge gas at high pressure (100 psi, for example). As will be appreciated by those skilled in the art, the applications of high pressure purge gas and vacuum are alternately applied for a predetermined number of cycles.

From the above description of the low paths in valve block 102, it will be understood that there are no dead-legs in valve block 102 during either the purge or evacuation phases of the purge cycle. The same can be said of valve block 104, since the flow paths therein during application of purge gas correspond exactly to the flow paths in valve block 102, with HPV valve 120 corresponding to HPI valve 204 and HPP valve 118 corresponding to HPB valve 202. During evacuation, the gas is drawn out through HPV valve 120, with HPP valve 118 closed, so that during this cycle, HPV valve 120 should be thought of as corresponding to HPB valve 202 and HPP valve 118 as corresponding to HPI valve 204. In both cases, however, valve block 104 is free of dead-legs. Also, as will be seen, a flow-through of purge gas will be applied to pigtail 164 in the next stage of the procedure so that pigtail 164 will not constitute a purge dead-leg.

## 2. Cylinder Change

Upon completion of the pre-purge cycles, purge gas is applied at low pressure through HPP valve 118 and HPB valve 202 (as well as the valve chambers 206 of closed HPV valve 120 and closed HPI valve 204). Then the cylinder 12 is disconnected, allowing the pigtail 164 to be flushed by the low pressure purge gas. It will be appreciated that this eliminates pigtail 164 as a dead-leg. After

a predetermined period of time for flushing pigtail 164, a new process gas cylinder 12 is connected to the pigtail 164.

### 3. Post-Purge

The cylinder change process then continues with a post-purge of the operation, which is divided into two portions: a connection test and the post-purging itself.

As a first step in the connection test, high pressure (100 psi) purge gas is applied through HPP valve 118 and HPB valve 202 to the pigtail 164. The HPB valve is then closed and pressure transducer 152 is monitored to determine whether a pressure drop is experienced in pigtail 164. If so, it is an indication that the new process gas cylinder 12 has not been properly connected. As a backup check, it is also preferable to use a helium sensor (not shown) to determine whether the purge gas, which is preferably a mixture of N<sub>2</sub> and He, is present in the vicinity of pigtail 164. Assuming that both of the checks find no leak, then HPP valve 118 is closed, and HPV valve 120 and HPB valve 202 are opened to evacuate the pigtail 164. Then HPB valve 202 is closed and pressure transducer 152 again is monitored to determine whether a vacuum is retained in the pigtail 164. Again, if not, it is an indication that the process gas cylinder 12 was not properly connected.

Assuming that no problem is detected in any of the connection tests, then the post purging of the high pressure area begins. Accordingly, HPB valve 202 is opened and remains open throughout the post-purging cycles. The post-purging cycles take the same form as the pre-purging cycles, described above, with alternate applications of purge gas through HPP valve 118 and applications of vacuum through HPV valve 120. After a predetermined number of cycles, and ending with an evacuation operation, the post-purging is complete and HPB valve 202 is closed.

### 4. Refill

The final stage of the cylinder change operation is refilling of the manifold 100 with process gas. This begins with opening of cylinder valve 14. Next, HPI valve 204 is opened so that process gas flows from the cylinder 12 through both valve chambers 206 of valve block 102 and out through port 222 of valve block 102, and then through pressure regulator 22 into the regulated pressure area 160 of manifold 100. Next, the cylinder valve 14 is closed and LPV valve 126 is opened so that a vacuum is applied to manifold 100 through its low pressure area 160. For a predetermined number of cycles, application of process gas through valve 14

is alternated with application of a vacuum through LPV valve 126, so that all of the residual purge gas is flushed from manifold 160 and pigtail 164. It will be noted that there are no dead-legs either in valve block 102, since the process gas flows through both of the valve chambers 206 of valve block 102, or in valve block 106, since the process gas also flows through both of the valve chambers 206 of valve block 106. More specifically, it is to be noted that when vacuum is applied to the manifold 100 through regulated pressure area 160, the process gas vented flows through the valve chamber 206 of closed LPI valve 124 as well as valve chamber 206 of open LPV valve 126. After the purge gas refill and alternating vacuum cycle is performed a predetermined number of times, the manifold is again filled with process gas, with LPV valve 126 being closed, and process gas can then be delivered to the tool location by opening LPI valve 124.

As will be appreciated from the disclosure of the above referenced Patent No. 4,989,160, the above-described pre- and post-purge and process gas refill operations, as well as at least some of the leak checking operations, may be automatically performed by an automatic gas cabinet, with some or all of the purge cycle parameters and pressure set points being subject to user programming.

There will now be described, with reference to Figures 6, 7 and 8A-8D, a purge gas manifold 300 which may be installed in association with the gas cabinet manifold 100 of Figure 3.

From Figure 6, it will be seen that purge gas manifold 300 consists largely of a valve block 302 connected to a purge gas cylinder 312. The valve block 302 is, in schematic terms, equivalent to the valve block 102 shown in Figure 4A, but preferably valve block 302 has its two valves 202' and 204' in a "V" configuration (see, for example, Figures 7 and 8B) rather than in an opposed orientation as in Figure 4A.

Further, the diaphragm positioning mechanism of valve block 302 is preferably manually actuated, rather than pneumatic, and so includes handles 334 (Figure 7). The additional safety feature of pneumatically operated valves is not required in purge gas manifold 300 since only inert, non-toxic purge gas is present therein. The "V" configuration of the valves is provided in block 302 in order to provide more convenient access to the handles 334 than would be present in an opposed arrangement of the valves.

The portions of the valves 202' and 204', corresponding to those of valves 202 and 204 shown in Figure 4A, can be readily seen from Figures 8A-8D, which need not be described in detail. Elements of valve block 302 which correspond to those of block 102 have been given the same reference numerals. It will be understood that Fig-

ure 8A is a plan view showing the valve chambers 206' of the valves 202' and 204', Figure 8B is a cross-sectional view of valve block 302 taken at line B-B of Figure 8A, Figure 8C is a cross-sectional view of valve block 302 taken at line C-C of Figure 8A, and Figure 8D is a cross-sectional view of valve block 302 taken at line D-D of Figure 8D. Figure 8B shows the conduit 226 which connects the respective second inlet ports 210 of valve chambers 206'; Figure 8C shows conduits 216 and 220 which respectively connect the selectively closable outlet ports 212 and 214 with ports 218 and 222; and Figure 8D shows the conduit 224 which connects the respective first inlet ports 208 with port 230.

Although it would be possible to use manually actuated valve blocks like block 302 in place of the pneumatically actuated valve blocks 102, 104 and 106 shown in manifold 100 (Figure 3), this is not preferred, since the safety and convenience provided by automatic operation through automatic control, as well as automatic shut-down in case of a malfunction, are desired for gas cabinet manifold 100.

Operation of purge gas manifold 300, and further details thereof, will now be briefly described with reference to Figure 6. Purge gas cylinder 312 is connected to port 230 of valve block 302 via cylinder valve 314 and a pigtail 315, a filter 316 and a pressure transducer 318. Port 222 of valve block 302 is connected to the port 222 of valve block 104 (Figure 3) by way of a pressure regulator 320, a pressure transducer 322 and a filter 324 (Figure 6). Accordingly, the outlet of the valve 204' is connected to the outlet of HPP valve 118 (Figure 3). Referring again to Figure 6, port 218 of valve block 302 (and hence also outlet 212 of valve 202') is connected to an exhaust vent (not shown).

When purge gas is to be supplied to the gas cabinet manifold 100, valve 202' of valve block 302 is closed and cylinder valve 314 and valve 204' of valve block 302 are opened. This allows purge gas to flow from cylinder 312 through cylinder block 302 and pressure transducer 320 to port 222 of cylinder block 104 (Figure 3) and HPP valve 118.

More specifically, the purge gas flows from pigtail 315 into valve block 302 via its port 230 and then flows through both valve chambers 206' of the closed valve 202' and the open valve 204'; exiting from valve block 302 via outlet port 214 of valve 204', as well as conduit 220 and port 222 of valve block 302. Accordingly, it will be seen that there are no dead-legs in the valve block 302 during delivery of purge gas to gas cabinet manifold 100.

When it is desired to change purge gas cylinder 312, there is no requirement for a pre-purge, since the purge gas is not toxic. Accordingly, valve 204' is simply closed and the purge gas cylinders

312 exchanged. A post-purge or flushing of the manifold 300 to remove contaminants can be accomplished by opening valve 202' and cylinder valve 314, so that purge gas flows through both of valve chambers 206' on its way out to the exhaust vent via port 218. It will be recognized that there are no dead-legs in purge gas manifold 300 during the flushing operation.

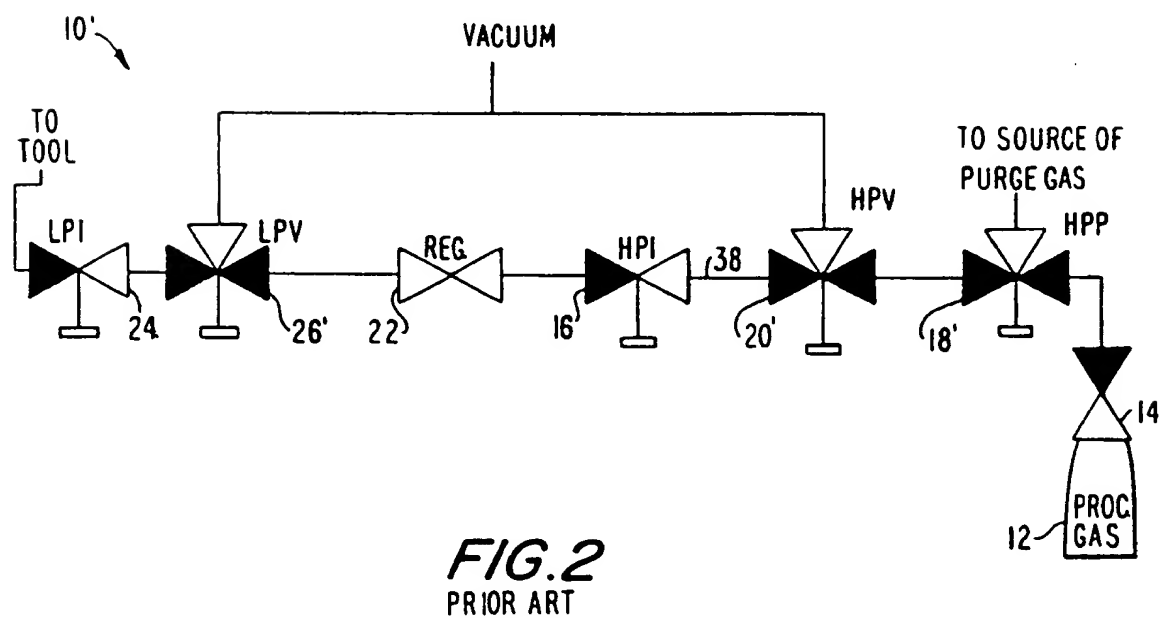
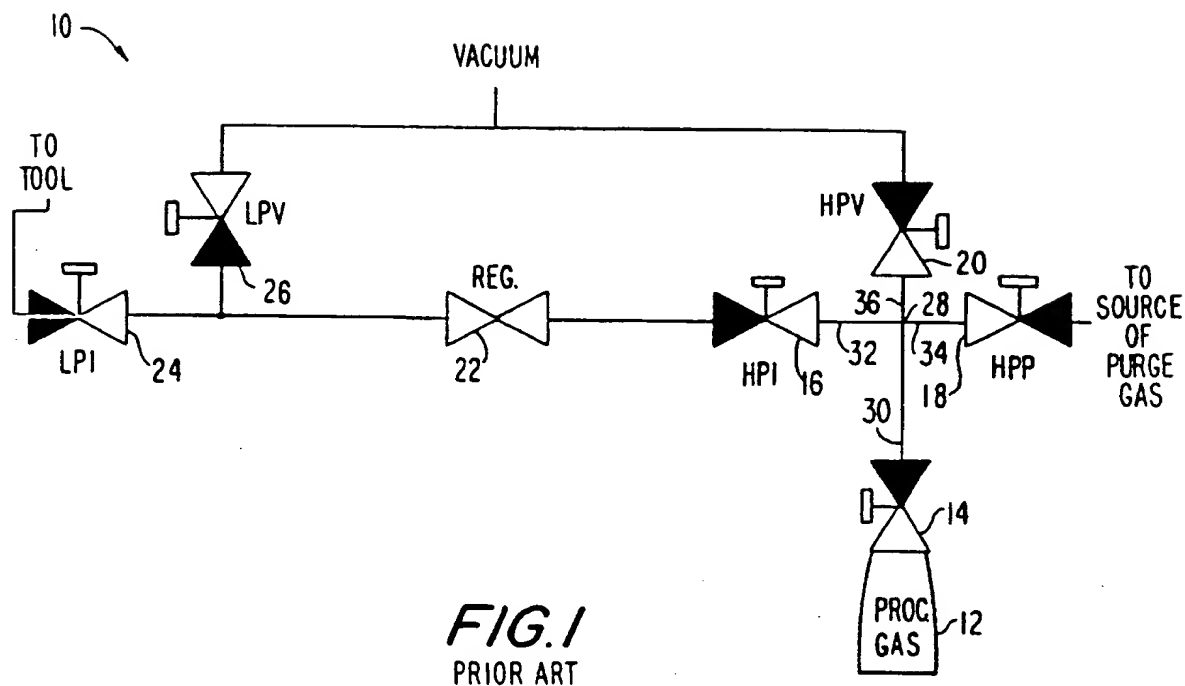
## Claims

1. A valve assembly comprising two valves for selectively controlling flow of a fluid, each of said valves including:  
a valve chamber in which are formed first and second inlet ports and an outlet port; and  
closing mechanism disposed within said valve chamber for selectively closing said outlet port; the valve assembly further comprising a first conduit connecting the respective first inlet ports of said two valves, a second conduit connecting the respective second inlet ports of said two valves, and means for introducing said fluid into said first conduit.
2. A manifold for supplying process gas to a tool location, the manifold including a pressure regulator connected between a high pressure area and a regulated pressure area, a pair of valves according to the assembly of Claim 1, the outlet port of one of said valves being connected for fluid communication with a high pressure side of said pressure regulator, the outlet port of the other of said valves being selectively connectable for fluid communication with at least one of a source of purge gas and a source of vacuum, said first conduit being connected in common for fluid communication with a source of process gas.
3. A manifold according to Claim 2 further comprising a second and a third pair of valves according to claim 1, the outlet port of one of said second pair of valves being connected for fluid communication with a vacuum source, the outlet port of the other of said second pair of valves being connected to a source of purge gas, said first conduit of said second pair of valves being connected in fluid communication with the outlet port of said other of said first pair of valves; and the outlet port of one of said third pair of valves being connected for fluid communication with said tool location, the outlet port of the other of said third pair of valves being connected for fluid communication with said source of vacuum, said first conduit of said third pair of valves being connected in fluid communication with said pres-

sure regulator.

4. A manifold according to Claim 2 or Claim 3 in which each of said pairs of valves is formed by a respective dual valve assembly block, and said three valve blocks are substantially identical.
5. A manifold for supplying process gas to a tool location, the manifold including a regulated pressure area, a pair of valves each according to the assembly of Claim 1, the outlet port of one of said valves being connected for fluid communication with said tool location, the outlet port of the other of said valves being connected for fluid communication to a source of vacuum, said first conduit being connected in fluid communication with said regulated pressure area.
6. A manifold for supplying process gas to a tool location, the manifold including a high pressure area, a pair of valves each according to the assembly of Claim 1, the outlet port of one of said valves being connected for fluid communication with a source of vacuum, the outlet port of the other of said valves being connected for fluid communication with a source of purge gas, said first inlet ports being connected in common and being selectively connectable for fluid communication with said high pressure area, and said second inlet ports being interconnected for fluid communication therebetween.
7. A purge gas manifold for use in association with a gas cabinet manifold, a pair of valves each according to the assembly of Claim 1, the outlet port of one of said valves being connected for fluid communication with said gas cabinet manifold, the outlet port of the other of said valves being connected for fluid communication with an exhaust vent; said first conduit being connected in fluid communication with a source of purge gas.
8. A valve assembly according to any preceding claim in which each said closing mechanism includes a metal diaphragm and means for pneumatically controlling positioning of said metal diaphragm.
9. A valve assembly according to Claim 8 in which each said closing mechanism also includes means for manually controlling positioning of said metal diaphragm.

10. A gas cabinet manifold which includes a pressure regulator connected between a high pressure area and a regulated pressure area, a process gas conduit connected to said high pressure area and a valve located in said high pressure area for selectively isolating said pressure regulator from said process gas conduit, a method of purging said process gas conduit comprising the steps of:  
closing said valve; and  
flowing a purge gas through a valve chamber of said closed valve to said process gas conduit.
11. A gas cabinet manifold which includes conduit means for providing process gas to a tool location, an isolation valve for selectively connecting said conduit means to said tool location and a vent valve for selectively connecting said conduit means to a vacuum source, a method of purging said conduit means comprising the steps of:  
closing said isolation valve;  
opening said vent valve; and  
flowing gas from said conduit means to said vacuum source via a valve chamber of said closed isolation valve.



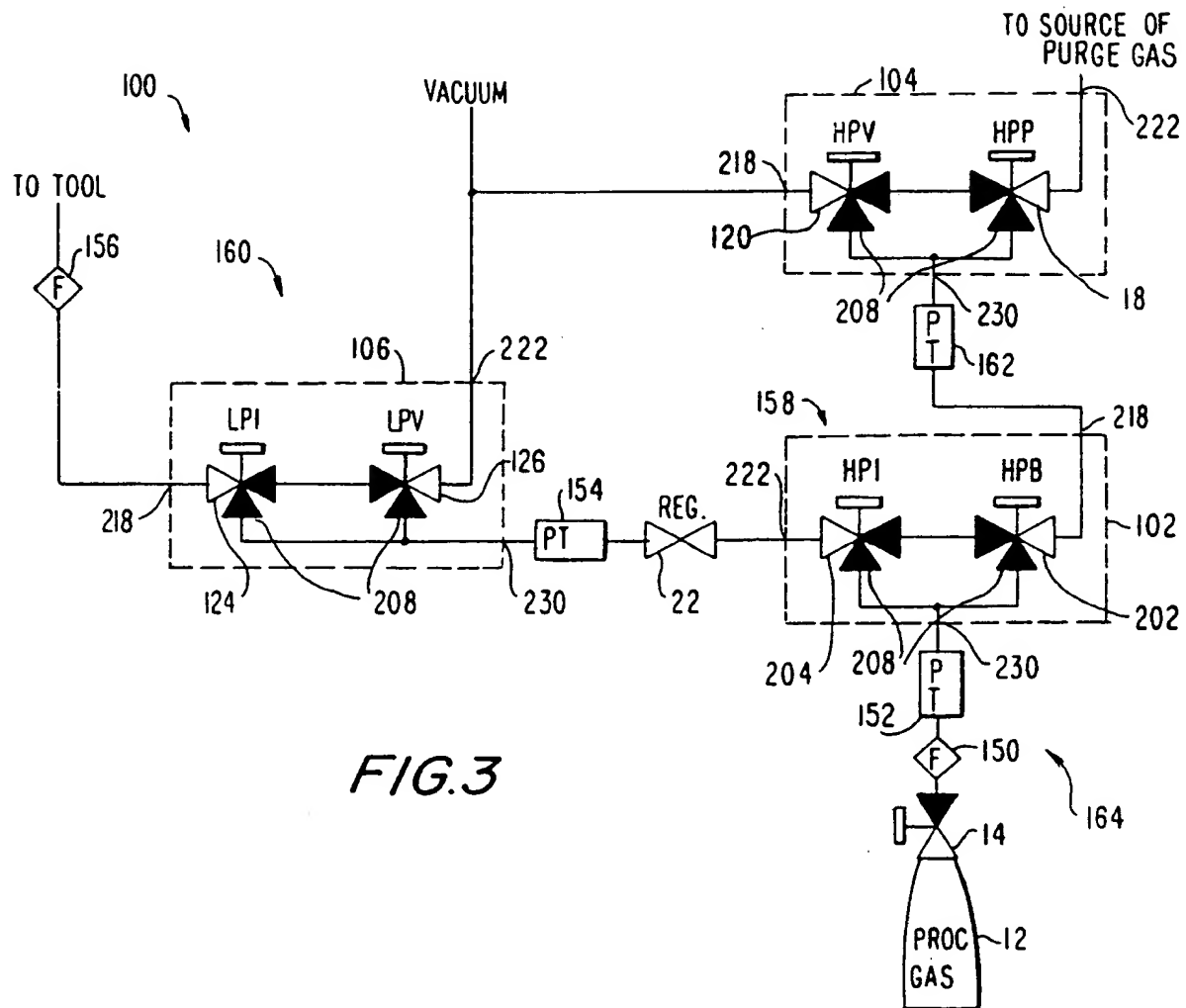


FIG.3

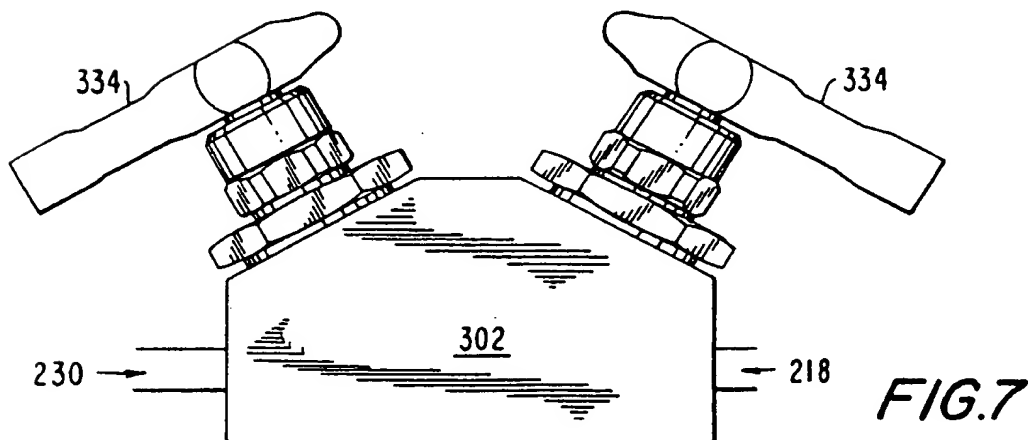
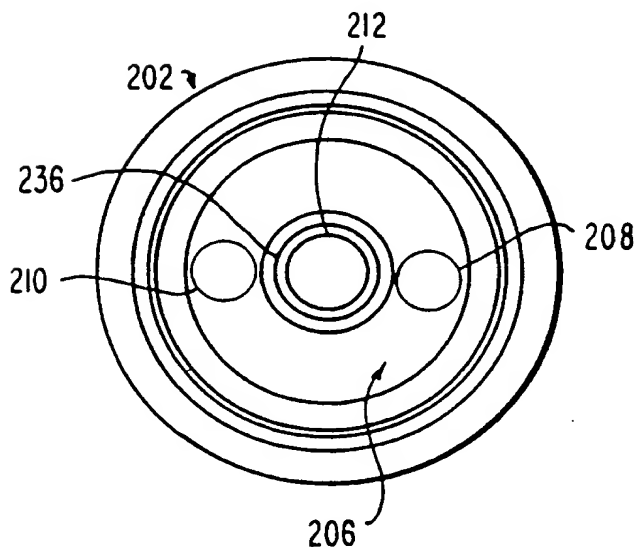
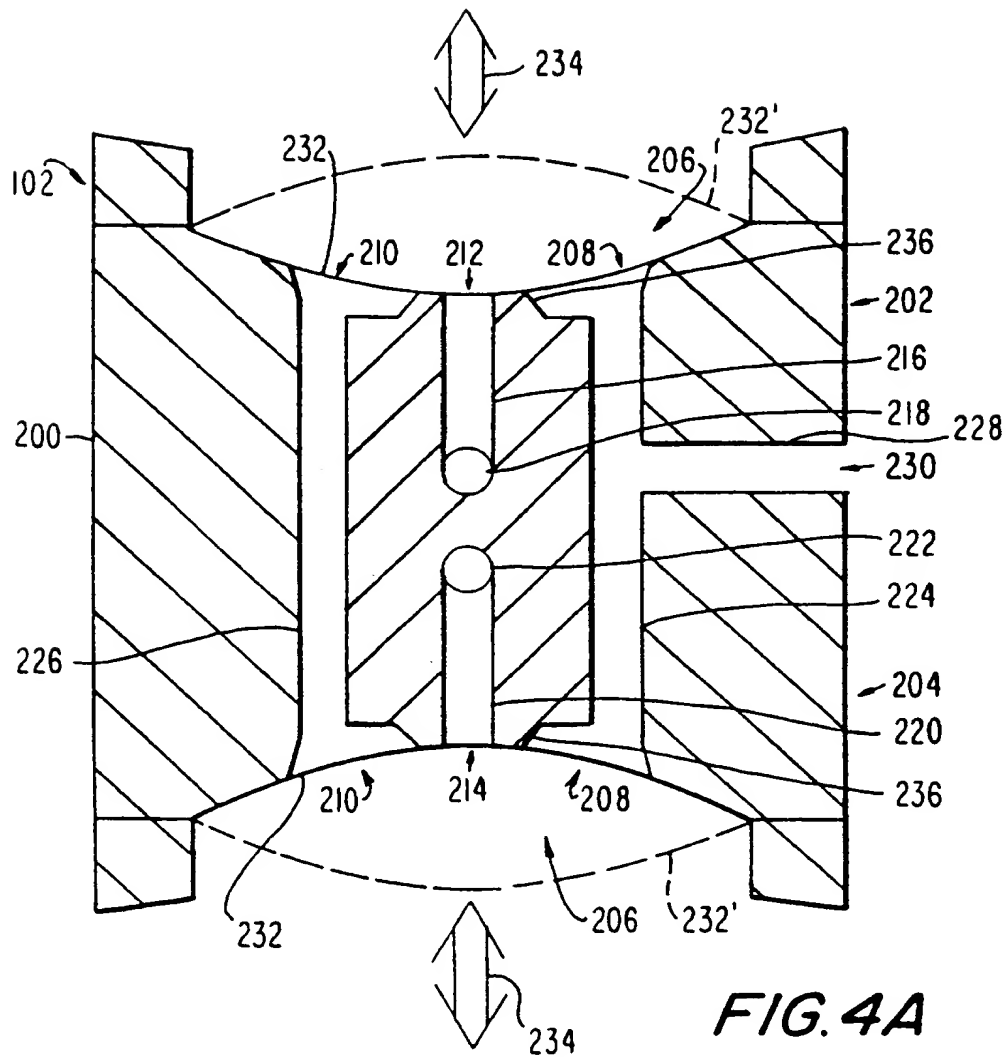
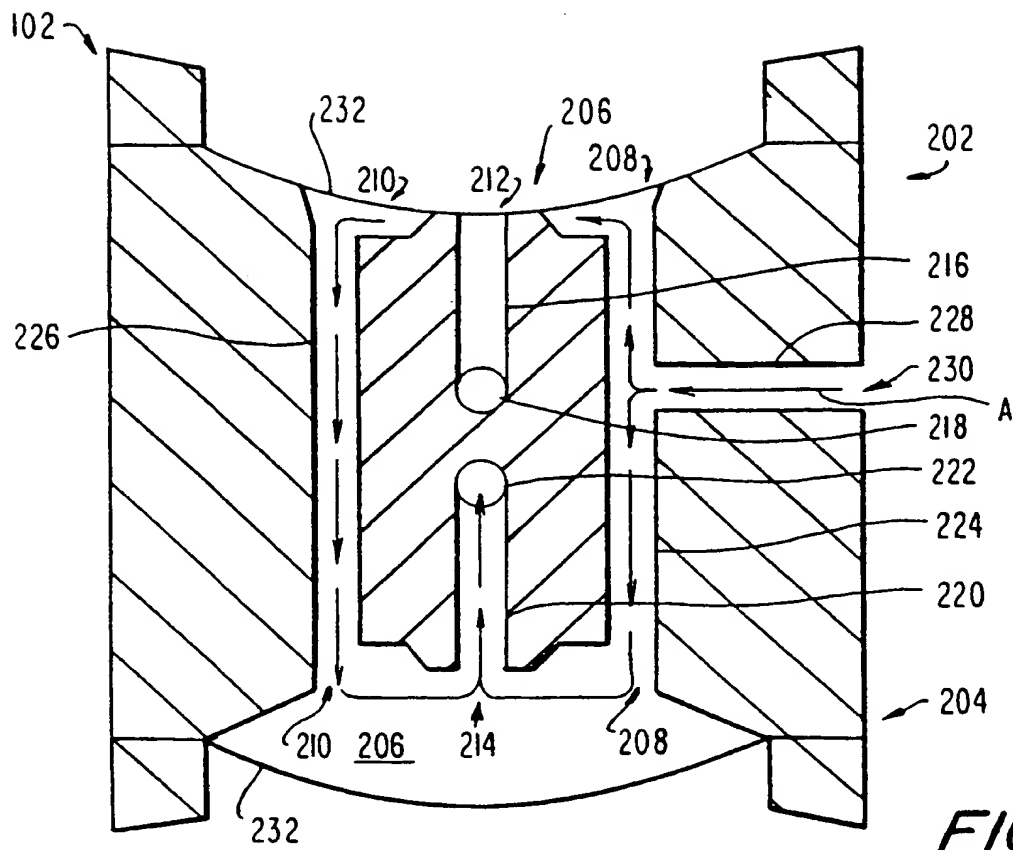
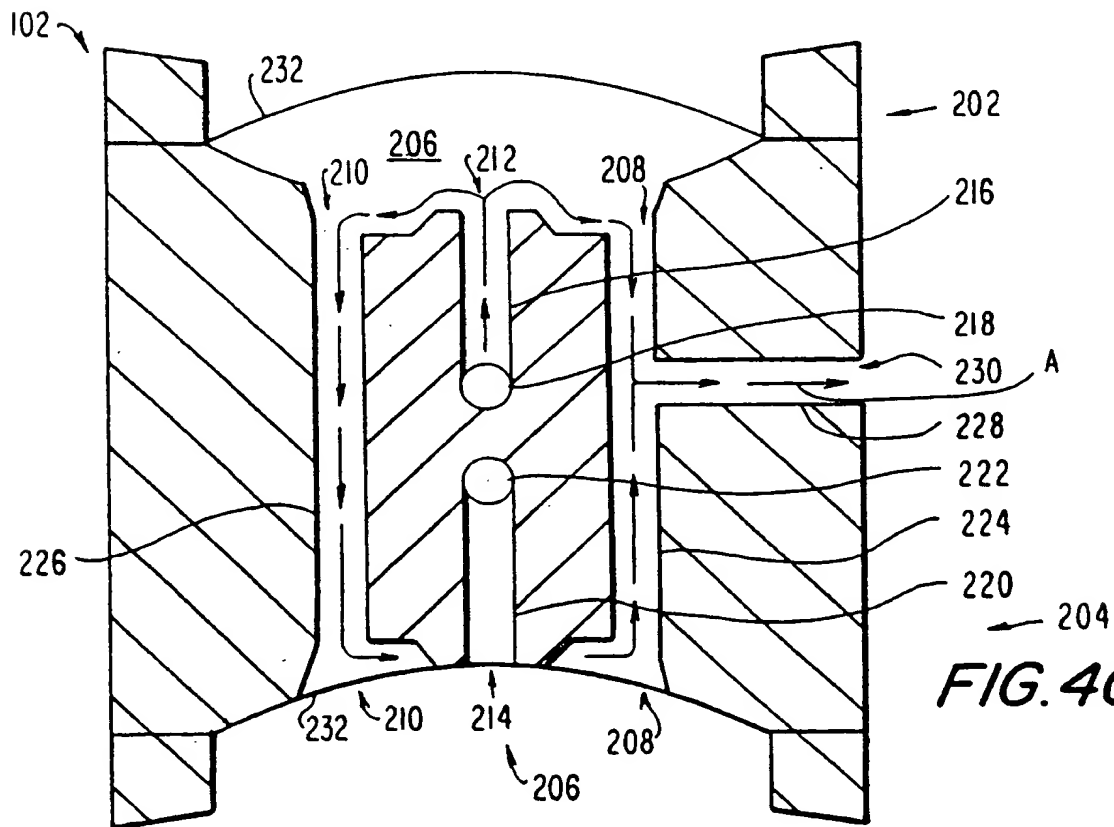


FIG.7



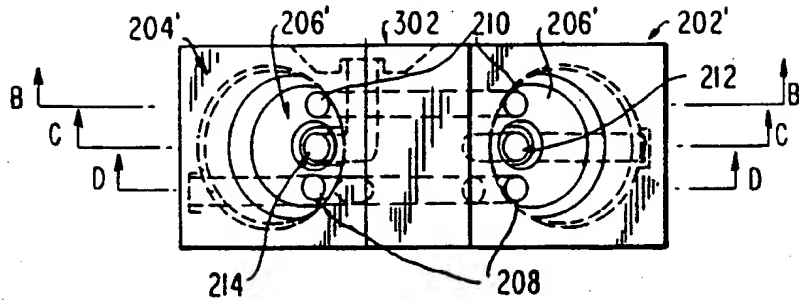


**FIG. 4B**

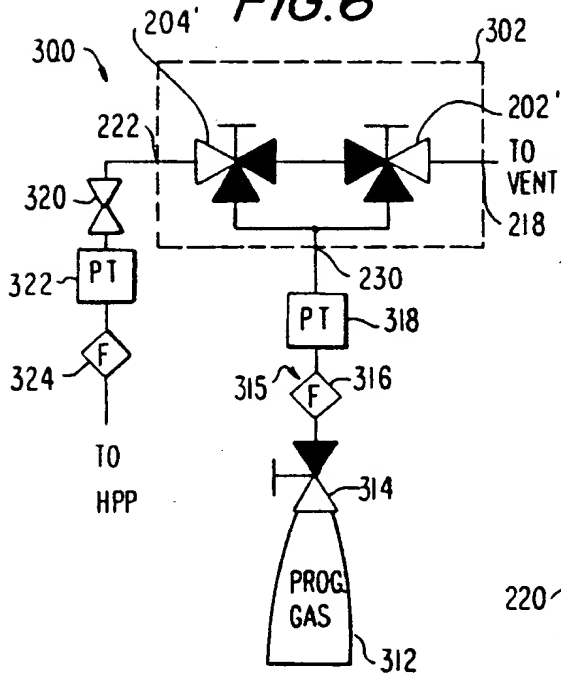


**FIG. 4C**

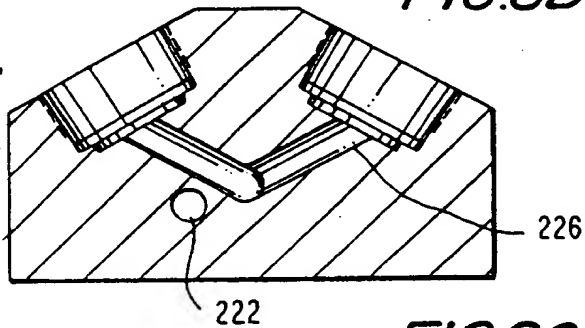
**FIG. 8A**



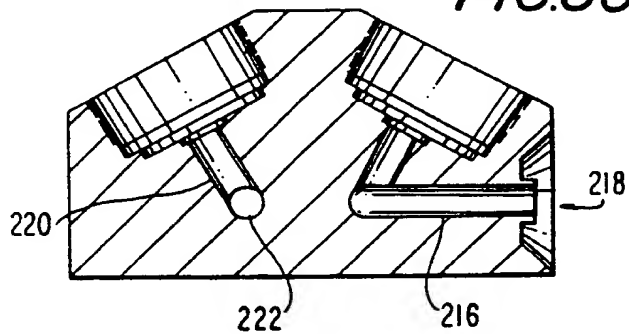
**FIG. 6**



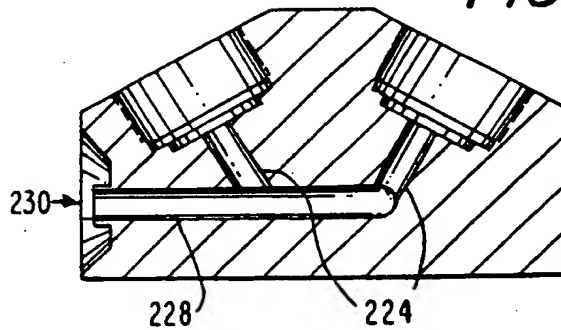
**FIG. 8B**



**FIG. 8C**



**FIG. 8D**





European Patent  
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## EUROPEAN SEARCH REPORT

Application Number  
EP 94 30 2542

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	EP-A-0 488 117 (UNION CARBIDE INDUSTRIAL GASES TECHNOLOGY CORP.) * abstract * * page 4, line 13 - page 5, line 9; figures 1,2 *	1	F16K27/00 F16K11/22 F17D1/04
A	WO-A-87 02598 (AIXTRON GMBH) * abstract * * page 8, paragraph 2 - page 9, paragraph 2; figures 1,2 *	1	
D,A	US-A-4 989 160 (GARRETT) * abstract; figures 4,12 *	1-7,10,11	
D,P, A	US-A-5 220 517 (SIERK) * figure 8 *	1-7,10,11	
A	US-A-5 139 225 (OLSON) * column 3, line 23 - line 53; figure 1 *	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			F16K F17D
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 22 July 1994	Examiner Christensen, J
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application I : document cited for other reasons & : member of the same patent family, corresponding document	